systems. For example, a sensing system which is light weight and easily mounted to an item of interest may provide continuous monitoring and enable a capacity for dynamically reconfiguring a circuit board for internal physical damage that may be caused by events such as physical trauma, shock, vibration or heat.

Sensing systems may also be used to identify breached containers holding sensitive documents, information, or materials. Such sensing systems should be easily monitored such that mitigation actions may be taken in real time before information/material is unrecoverable. Improvements to existing sensing technology are needed to detect a breach of any type of container for commercial or military use, and relay that breach to a monitoring system.

According to an illustrative embodiment of the present disclosure, a system is provided to produce real-time information on a variety of damage events, including structural, perimeter, and/or armor integrity failure conditions of a monitored device or unit by means of a resistive/conductive sensor system. One illustrative embodiment of the present disclosure provides sensors to areas where impacts may occur from a ballistic means or other known or unknown sources. Exemplary ballistic strike detection methods and structures may be used to pinpoint a location of an impact site, provide an estimation of the ballistic object's relative velocity, and provide an estimation of the ballistic object's size.

According to an illustrative embodiment of the present disclosure, a detection system includes a first layer adapted to a damage event, the first layer adapted to conduct an electromagnetic signal and having a plurality of electromagnetic signal measuring portions oriented in a first orientation. At least one coupling point is in electrical communication with at least one of the signal measuring portions of the first layer and is adapted to receive an electromagnetic signal input. An electromagnetic signal generator is coupled to the at least one input coupling point to provide the electromagnetic signal input. At least one output coupling point is in electrical communication with at least one of the signal measuring portions of the first layer and is adapted to provide an electromagnetic signal output. An electromagnetic signal measuring device is coupled to the at least one output coupling point. A processing system is adapted to control the electromagnetic signal generator and the electromagnetic signal measuring device, wherein the processing system is adapted to determine data on the damage event based on changes between the electromagnetic signal input at the at least one input coupling point and the electromagnetic signal output at the at least one output coupling point. The damage event may be further determined from an electromagnetic signal change calculation which is based on a comparison between a first electromagnetic signal measuring portion and a second electromagnetic signal measuring portion. Illustratively, an output device is adapted to produce damage data comprising a at least one of a damage alert, damage location, damage size, damage orientation, time data, and damage event category.

According to a further illustrative embodiment of the present disclosure, a detection system includes a sensing device configured to be operably coupled to a structure of interest and to sense a damage event. The sensing device includes a first layer, and a plurality of measuring portions supported by the first layer, each of the measuring portions including an input coupling point and an output coupling point and adapted to conduct an electrical signal from the input coupling point to the output coupling point. A measurement system is in electrical communication with the measuring portions of the sensing device, the measurement system configured to provide electrical signal inputs to the input coupling points of the sensing device, and configured to measure electrical signal outputs at the output coupling points of the sensing device. A damage detection processing system is operably coupled to the measurement system, the processing system configured to determine data on the damage event based on changes between the electrical signal inputs at the input coupling points and the electrical signal output sat the output coupling points, the data including a location of the damage event on the sensing device and a damage event origination axis directed to the point of origin of the damage event. A user interface is operably coupled to the damage detection processing system and is configured to provide a visual display of the damage data including a representation of a damage alert, the damage event location and the damage event origination axis.

According to another illustrative embodiment of the disclosure, a method of detecting a damage event associated with a structure of interest includes the steps of coupling a first layer to a structure of interest, the first layer including a plurality of measuring portions oriented in a first direction, providing input electrical signals to input coupling points of each of the measuring portions, and measuring output electrical signals from output coupling points of each of the measuring portions. The method further includes the step of determining data on a damage event based on changes between the electrical signal inputs at each of the input coupling points and the electrical signal outputs at each of the output coupling points.

According to a further illustrative embodiment of the disclosure, a vehicle damage detection system includes a plurality of sensing devices supported by a vehicle and defining a sensing perimeter. Each of the sensing devices includes a layer, and a plurality of measuring portions supported by the layer, each of the measuring portions including an input coupling point and an output coupling point and adapted to conduct an electrical signal from the input coupling point to the output coupling point. A measurement system is in electrical communication with the measuring portions of each of the sensing devices. The measurement system is configured to provide electrical signal inputs to the input coupling points of each of the sensing devices, and is configured to measure electrical signal outputs at the output coupling points of each of the sensing devices. A plurality of couplers secure the plurality of sensing devices to an exterior of the vehicle. A damage detection processing system is operably coupled to the measurement system, and is configured to determine data on a damage event from the sensing devices based on changes between the electrical signal inputs at the input coupling points and the electrical signal outputs at the output coupling points, the data including a location of the damage event on the sensing device and a damage event origination axis directed to the point of origin of the damage event.

According to another illustrative embodiment of the present disclosure, a method of manufacturing a vehicle damage detection system includes the steps of preparing an outer surface of a vehicle to facilitate coupling thereto, applying a first electrically isolating material to the prepared surface of the vehicle, applying a first electrically conductive layer on the electrically isolative material, installing a plurality of electrical interconnects on the first electrically conductive layer, coupling the plurality of electrical interconnects to a measurement system, and applying an overcoat layer to the conductive layer and electrical interconnects.